Physical Fitness and Injuries Before and After Deployments of the United States (US) Army to Afghanistan and Iraq

Marilyn A. Sharp, Mark E. Lester
United States Army Research Institute of Environmental Medicine (USARIEM)
42 Kansas Street
Natick, MA 01760
USA
Telephone: 508.233.6272 / Fax: 508.233.4195

E-mail: marilyn.sharp@us.army.mil

Joseph J. Knapik
US Army Center for Health Promotion and Preventive Medicine
ATTN: MCHB-TS-DI
1570 Stark Road
Aberdeen Proving Ground MD 21010
USA

SUMMARY

Physical training and avoidance of injury is critical to maintaining the health and performance of soldiers. Anecdotal reports from United States (US) Army unit leaders and healthcare providers suggest deployed soldiers experience losses in fitness and muscle mass and have higher injury rates compared to those experienced prior to deployment. Confirming or countering these reports is particularly important since soldiers are called upon for repeated deployments.

Rationale

The purpose of this paper is to report on studies examining changes in physical fitness and injury incidence following US Army combat deployments.

Methods

Body composition, physical fitness, and injury incidence were evaluated before and after deployments of US Army combat soldiers to Afghanistan (AF) and Iraq (IQ). Injury incidence was determined from a review of Soldier's medical records.

Results

Fitness measures obtained immediately before and after 9 months deployment to AF (n=110) demonstrated a decline of 5% in treadmill VO_2peak (pre=50.8±6.1, post=48.5±5.7 $ml \cdot kg^{-1} \cdot min^{-1}$, <0.01), and medicine ball put performance (pre=679±80, post=645±73 cm, p<0.01), while vertical jump performance and lifting strength were unchanged. Body fat, measured by dual X-ray absorptiometry, increased 8% (pre=15.1±7.5, post=16.3±7.5 kg, p<0.01) while fat-free mass declined 4% (pre=62.8±7.3 kg, post=60.6±6.9 kg, p<0.01). Injury incidence for the full battalion of Soldiers deployed to AF (n=505) was identical in two consecutive

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
OCT 2009	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Physical Fitness and Injuries Before and After Deployments of the United States (US) Army to Afghanistan and Iraq	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **United States Army Research Institute of Environmental Medicine (USARIEM) 42 Kansas Street Natick, MA 01760 USA**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADA562561. RTO-MP-HFM-181 Human Performance Enhancement for NATO Military Operations (Science, Technology and Ethics) (Amelioration des performances humaines dans les operations militaires de l'OTAN (Science, Technologie et Ethique)). RTO Human Factors and Medicine Panel (HFM) Symposium held in Sofia, Bulgaria, on 5-7 October 2009., The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**16**	

90-day pre-deployment periods (14.1% and 14.1%), but elevated in the two consecutive 90-day post-deployment periods (16.4% and 23.4%). Among Armored Cavalry Soldiers deployed for 13 months in IQ (n=73), there was a post-deployment decline of 13% in 2-mile run time (pre=15.7±1.4, post=17.7±2.5 minutes, p<0.01), but post-deployment increases in strength of 7% for bench press (pre=79±17, post 85±21 kg, p<0.01) and 8% for squat (pre=100±21, post=108±23 kg, p<0.01). Bench press power increased 9% post-deployment (pre=526±137, post=572±143 watts, p<0.01), but squat jump power was unchanged. Body fat increased 9% (pre=13.4±5.3, post=14.5±5.6 kg, p<0.01) while fat-free mass increased 3% (pre=58.3±5.8, post=60.1±6.2 kg, p<0.01). Of 3,242 soldiers deployed to IQ, injury incidence was elevated in both of the two consecutive 90-day post-deployment periods (35.4% and 43.4%, respectively) when compared to the two consecutive 90-day pre-deployment periods (15.1% and 12.4%, respectively).

Conclusions

These results suggest that the deployments decreased aerobic fitness and increased body fat, likely due to decreased aerobic training. Strength was differentially affected by the AF and IQ deployments possibly reflecting differences in physical training habits or mission requirements in-theater. The soldiers returning from both deployments showed increased injury incidence, although the pattern and magnitude of the increases differed. Elevated injury rates may be associated with a variety of intrinsic factors (e.g., post-traumatic stress, unhealthy coping behaviors, or increased risk taking) or extrinsic factors (e.g., physical training, seasonal differences, or exposures in-theater). Soldiers returning from deployment in these combat settings did not demonstrate deleterious changes in strength and only marginal reductions in aerobic performance with concomitant increases in fat mass. These negative changes will likely be ameliorated with a directed PT program upon return from deployment. The elevated post-deployment injury incidence should be examined further to determine the etiology.

1.0 INTRODUCTION

United States (U.S.) Army physical training is designed to prepare a Soldier for the physically demanding tasks performed during military operations. Physical training in a non-deployed setting is considered a job requirement and time is set aside during the day for mandatory exercise sessions. In deployed combat environments the variability of mission requirements may prevent consistent exercise practices from being established and maintained. Lack of routine exercise, may in turn diminish components of fitness required for optimal job performance and may increase the risk of injury. Lower physical fitness has been shown to be a risk factor for injury and improving physical fitness lowers injury risk (1-3). On the other hand, the physical requirements of the deployment (e.g., load bearing patrolling, convoys, preparing forward operating camps, lifting and carrying equipment) may offset some of the deleterious effects associated with the lack of scheduled exercise.

There is limited data available to describe the effects of a land-based combat deployment on body composition and physical fitness in military personnel (4,5). Individual U.S. Army units have reported concerns over increases in body fat mass, decreases in lean body mass, and decreases in strength following deployment; however these potential changes not been systematically evaluated. Loss of lean mass, muscle strength and endurance could negatively affect mission performance and military readiness. These changes may also negatively affect performance during training and other missions and increase the risk for injury upon return from deployment. The purpose of this paper is to describe the effects of combat deployments of US Army Soldiers on physical fitness, body composition and injury incidence.

2.0 METHODS

2.1 Subjects

For the detailed physiological and performance measurements, two samples of U.S. Army Soldiers were studied: 135 Infantry Soldiers who were deployed to Afghanistan (AF) for 9 months and 73 Armored Cavalry Soldiers who were deployed to Iraq (IQ) for 13 months. Soldiers were briefed on the requirements and risks of the respective studies and provided written informed consent. The AF Soldiers were members of the 2nd Battalion, 4th Infantry Regiment, 10th Mountain Division. Pre-deployment measurements were made in January and February 2006, prior to the battalion's deployment in March 2006. Post-deployment measurements were made as soon as possible upon redeployment and took place during December 2006. The IQ Soldiers were members of the 4th Heavy Brigade Combat Team, 1st Cavalry Division Soldiers. Pre-deployment measurements were made in September 2006, prior to the brigade's deployment in October and November of 2006. Post-deployment measurements were made within two weeks of the participants' return from the theatre of operations and took place during December 2007. Table 1 outlines the specific measures made with each unit. The injury data and Army Physical Fitness Test (APFT) data included the entire battalion and were collected from existing records after the units returned.

Table 1: Measurements made and data collected for the Infantry unit deployed to Afghanistan (AF) and the Armored Cavalry Unit deployed to Iraq (IQ).

	Infantry soldiers	Armored Cavalry soldiers
Dual Energy X-ray Absorptiometry Body Composition Measures	Hologic model QDR 4500W	Lunar model DPX-IQ
Strength	Incremental lifting strength	1-Repetition Maximum (1-RM) bench press, 1RM squat
Power	Vertical Jump, medicine ball put	Bench throw, Squat Jump
Aerobic Fitness	Treadmill VO2max	2 mile run
Physical Activity Questionnaire	X	X
Injury*	2 consecutive 90-day periods pre-deployment and 2 consecutive 90-day periods post-deployment	2 consecutive 90-day periods pre-deployment and 2 consecutive 90-day periods post-deployment
Army Physical Fitness Test*	4-6 months pre- and 5-6 months post-deployment	4-6 months pre- and 5-6 months post-deployment

* These data were collected from existing records for the entire unit, not just those Soldiers who volunteered for pre and post-deployment physical fitness testing.

2.2 Measurements

All Soldiers reported for testing wearing standard Army physical fitness shorts, t-shirts, socks and self-selected running shoes. The test battery was completed in approximately 3 hours. Physical testing was not conducted in a standardized order; however, a station requiring minimal physical exertion (body composition or questionnaires) was interspersed between stations requiring greater physical exertion (strength testing, running, and power testing). To control for order effects, each Soldier followed the same order of active events pre- and post-deployment.

Height (cm) was measured using a stadiometer (Portable Height Rod, Seca Scales, Hamburg, GE) and body weight (kg) was measured using a digital scale (Seca Alpha Model 770, Seca Scales, Hamburg, GE). Body composition was measured using Dual-Energy X-Ray Absoptiometry (DXA). For the AF Soldiers, a Hologic model QDR 4500W DXA densitometer (Hologic Inc., Bedford, MA) and Hologic software algorithms were used. For the IQ Soldiers, a Lunar model DPX-IQ DXA densitometer (Lunar Corp, Madison, WI) and Lunar algorithms were used. Both software systems provide estimates of percent body fat, absolute body fat, total fat-free mass, bone mineral content and bone mineral density. Soldiers were positioned supine on the DXA table with arms at their side. The feet were strapped together to maintain the correct position. The scanner head moved side to side across the body moving downward from head to toe. The precision of this measurement has been reported to be ±1% (6).

2.3 Strength and Anaerobic Power

The lifting strength of the AF Soldiers was measured using an incremental lifting machine. The test simulates lifting a box with handles from ground level onto the bed of a 5 ton military truck (175 cm final handle height). The weight carriage of the machine moves vertically between two guide rails. The weight carriage was accelerated upward by straightening the legs and pulling up on the handles until the load was pressed to the 175 cm mark on the vertical guides. The initial load was 18.2 kg and was increased in 9.0 kg or 4.5 kg increments until the Soldier was unable or unwilling to complete the lift. The last weight successfully lifted with correct form was recorded as the lifting strength (7,8).

The IQ Soldiers upper body strength was assessed using a 1-RM bench press lift of free weights (York Barbells, York PA). Lower body strength was assessed using a 1-RM squat lift of free weights (York Barbells, York PA) (9). Each volunteer performed a warm-up of 5-10 repetitions with a load of at least 40% of their perceived maximum. Subsequently, each subject performed repeated bouts of single repetitions at progressively greater loads until they were unwilling or unable to complete the lift through a full range of motion using proper form. Two spotters were used to ensure proper lifting technique and subject safety. All subjects were provided a 3-5 min rest between lifts (10). Proper form of the bench press was achieved when the bar was maintained parallel to the chest throughout the lift and was lowered from an elbow extended position to the level of the chest and returned to the elbow fully extended position. Proper form of the squat was achieved when the subject held the bar across his shoulders and, maintaining proper spinal mechanics, lowered himself by bending the knees to 90^{o} of flexion and then returning to the standing position.

The upper body explosive power of the AF Soldiers was measured using a two-handed medicine ball put (similar to a basketball push-pass). The Soldier sat in a chair placed against the wall, with his back pushed firmly against the chair back. A two-kg medicine ball was held in both hands. The Soldier touched his chest with the ball, paused, and pushed the medicine ball away as forcefully as possible. The final score was the average of the two furthest distances (in cm) thrown of three trials (11). The lower body explosive power of Infantry Soldiers was measured with a vertical jump using a Vertec™ device (12,13). Vertical jump height

was recorded as the distance from standing reach height to peak jump height to the nearest 1.3 cm (0.5 inch). The best of three trials was recorded as the vertical jump height.

Upper and lower body explosive power of the IQ Soldiers was assessed using a bench-throw and squat-jump, respectively, using a Max Rack (Max Rack, Inc. Columbus, OH) interfaced with a ballistic measurement system (Optimal Kinetics, Muncie, IN) (14). These movements were performed in a ballistic, explosive manner with a load equal to 30% of the 1-RM (15,16). The bench throw was performed by having the subject lower the bar to his chest and then throw it upward as fast as possible. The squat-jump was performed by having the subject hold the bar across his shoulders, lower his body by bending his knees to 90^{o} of flexion and jumping upward as fast as possible. Three measurements were obtained from which the average power (W) from each trial was calculated and averaged across all trials for analysis.

2.4 Aerobic Power/Endurance

Peak oxygen uptake (peak VO_2) of the AF Soldiers was measured using a continuous, uphill, treadmill running protocol (5,17). The Soldier breathed through a mouthpiece connected by a flexible hose to a ParvoMedics TrueMax 2400 metabolic measurement system (Salt Lake City, UT), which monitored oxygen uptake. A Polar Heartwatch was used to monitor heart rate. A 5 minute warm-up was run at 0% grade and 2.68 $m \cdot sec^{-1}$ (6 mph). If the heart rate was less than 150 $beats \cdot min^{-1}$ by minute five of the warm-up, treadmill speed was increased to 3.13 $m \cdot sec^{-1}$ (6.5 mph) for the remainder of the test. Following the warm-up, the treadmill grade was increased by 2.5% every 2 minutes until voluntary exhaustion. The Soldier was considered to be at peak VO_2 if oxygen uptake did not increase by at least 2 $ml \cdot kg^{-1} \cdot min^{-1}$ 1 minute after a grade increase. If the test was terminated due to volitional exhaustion, or if a plateau in oxygen uptake was not achieved, criteria for assessing peak VO_2 was: (1) heart rate in excess of 90% age-predicted maximum heart rate; and (2) respiratory exchange ratio in excess of 1.0.

Aerobic endurance of the IQ Soldiers was assessed by time to complete a maximal effort 2 mile run. Additionally, maximal aerobic capacity (VO_2 max) was estimated based on participant's run times using the equation VO_{2max} = 99.7 – 3.35 x 2 mile run time (min) – 0.25 x body weight (kg) (18).

2.5 Physical Activity Questionnaire

Soldiers completed a questionnaire concerning their customary level of physical activity and provided self-ratings of four components of physical fitness (endurance, sprint speed, strength and flexibility) (19). The questionnaire completed pre-deployment referred to the previous year, while the questionnaire completed post-deployment referred to the time deployed.

2.6 Army Physical Fitness Test

Semiannual Army Physical Fitness Test (APFT) data (including heights and weights) were provided by the units. Data were obtained for tests taken by Soldiers about 4 to 6 months prior to deployment and about 5 to 6 months after deployment. The APFT consisted of three events: the maximum number of push-ups completed in 2 minutes, the maximum number of sit-ups completed in 2 minutes, and a 2-mile run for time. A total age-adjusted "score" is also derived from performance on the 3 events (20).

2.7 Injury Data Collection

A list of deployed personnel was obtained from the Personnel Offices of the units shortly after they returned from their deployments. The list included those who were provided the physiological and performance testing

pre- and post-deployment. For the AF cohort, this included four rifle companies (n=505 men). For the IQ cohort, the list included all personnel (combat and support) who deployed with the unit (n=3,242 men). Medical data of the deployed personnel were requested from the Armed Forces Health Surveillance Center (AFHSC) for two consecutive 90-day periods just before the deployment (Periods 1 and 2) and two consecutive 90-day periods just after returning to the United States (Periods 3 and 4). The AFHSC returned visit dates and International Classification of Diseases, Revision 9 (ICD-9) codes for all outpatient medical visits within the four time periods. Cumulative injury incidences were compared across the four periods. An injury case was identified if a Soldier had a specific ICD-9 code that was included in the Installation Injury Index. The Installation Injury Index (III) has been used to compare injury rates among different military posts and is reported on a monthly basis at the Armed Forces Health Surveillance Center website (http://afhsc.army.mil/) where the specific ICD-9 codes used in the index are also provided. The first four diagnoses for each visit were considered, although a single visit usually included only one diagnosis.

2.8 Data Analysis

Physical fitness and body composition changes from pre- to post- deployment were analyzed using paired t-tests. Analyses of covariance (ANCOVA) were run to examine the effect of time between redeployment and testing on physical fitness and body composition. A Wilcoxon test was used to look at pre- to post-deployment changes in the distribution of responses to self-assessed physical fitness on the questionnaire.

Cumulative injury incidence for each of the Installation Injury Index was calculated for each of the four, 90-day periods as:

$$[(\sum \text{Soldiers with} \geq 1 \text{ injury visits} / (\sum \text{of all Soldiers})] \text{ X } 100\%.$$

Comparisons of cumulative injury incidence between each of the four periods were determined by the McNemar Test. The McNemar Test allows for comparison of frequency data involving repeated measures on the same individuals (21).

3.0 RESULTS

3.1 Descriptive Measures Pre- to Post-Deployment

The 110 Infantry soldiers included in the analyses were deployed to Afghanistan 258 ± 18 days (mean ± SD). The deployment times ranged from 208 days (7 months) to 318 days (10 months), but the majority of AF Soldiers (89%) were deployed between 8 and 9 months. The average time between redeployment and testing was 18 ± 14 days. At the pre-deployment measurement, the AF Soldiers ranged in age from 18 to 43 years, with an average of 23 ± 5 years. The height ranged from 160 to 201 cm, with an average of 178± 7 cm.

The 73 Armored Cavalry soldiers who completed testing had been deployed to Iraq between 376 days (13 months) and 411 days (14 months) with an average of 404 ± 6 days (14 months). Post-deployment, all returning IQ Soldiers were tested within 11 days of their return (mean 6 ± 2 days) and 85% were tested within 7 days of their return. They were between 18 and 39 years old (mean 24 ± 5 yrs). Their height ranged from 157 cm to 191 cm (mean 174 ± 7 cm).

Body mass and composition are shown for AF and IQ Soldiers from pre- to post-deployment in Table 2. Body mass and fat free mass decreased from pre- to post-deployment in the AF Soldiers, while body fat

(percent and kg) increased. In IQ Soldiers there was a small, but significant increase in body mass during deployment due to increases in lean mass and fat mass. Bone mineral content decreased in AF and increased in IQ, but the changes were minimal.

Table 2: Body mass and composition changes from pre- to post-deployment.

	Cohort	Pre-Deployment	Post- Deployment	Change (%)[a]
Body Mass (kg)	AF	83.3 ± 14.7	81.7 ±13.2	-1.9[1]
	IQ	76.6 ± 10.2	78.8 ± 10.6	+2.9[1]
Fat Free Mass (kg)	AF	62.8 ±7.3	60.6 ±6.9	-3.5[1]
	IQ	58.3 ± 5.8	60.1 ±6.2	+3.1[1]
Body Fat (%)	AF	17.7 ±6.4	19.5 ±6.5	+10.2[1]
	IQ	18.9 ±5.5	19.9±5.6	+5.3
Body Fat (kg)	AF	15.1 ±7.5	16.3 ±7.5	+7.9[1]
	IQ	13.4 ±5.3	14.5±5.6	+8.2[1]
Bone Mineral Content (g)	AF	3550 ± 475	3423 ± 468	-3.6
	IQ	3371 ± 481	3449 ± 493	+2.3[1]

[a] (Post-Pre)/Pre x 100, [1] Significant change pre- to post deployment ($P<0.01$)

3.2 Physical Fitness and Performance Pre- to Post-Deployment

The results of the pre- and post-deployment physical fitness measurements are listed in Table 3 for both samples of Soldiers. A repeated measures analysis of covariance was conducted using the number of days between redeployment and physical performance testing as the covariate. The covariate did not reach statistical significance for any of the measures. This indicates that time lag between redeployment and testing did not have a strong influence on the changes in body composition or physical fitness measurements. Both groups exhibited a decline in aerobic power or aerobic performance from pre- to post-deployment. Using the Mello et al (18) equation to predict VO_{2max} from run time, the predicted VO_{2max} of IQ Soldiers decreased 6.6 $ml \cdot kg^{-1} \cdot min^{-1}$. The decrease in the IQ Soldiers tended to be greater than that of the AF Soldiers.

There was no change in lifting strength of AF Soldiers from pre- to post-deployment. In contrast, upper and lower body strength increased in IQ Soldiers by 7% and 8% respectively. Upper body power decreased 5% from pre- to post-deployment for the AF Soldiers and increased 9% in the IQ Soldiers. Lower body power was unchanged in both groups.

Table 3: Physical fitness measured pre- and post-deployment to Afghtanistan (AF) and Iraq (IQ).

	AF		IQ	
	Strength			
	Lifting Strength (kg)		Bench Press 1RM (kg)	Squat 1RM (kg)
Pre (SD)	74.6 ± 12.9		79.1 ± 17.4	99.7 ± 20.9
Post (SD)	74.6 ±12.9		84.9 ± 20.9	107.8 ± 23.4
% Change	0.0		7.3[1]	8.1[1]
	Power			
	Ball Put (cm)	Vertical Jump (cm)	Bench-Throw (W)	Squat-Jump (W)
Pre (SD)	67.9 ±80	51.2 ± 9.0	526 ± 137	1856 ± 272
Post (SD)	645 ±73	51.7 ± 8.3	572 ± 143	1857 ± 333
% Change	-4.9[1]	0.1	8.7[1]	0
	Aerobic Performance			
	Peak VO_2 ($l \cdot min^{-1}$)	$VO_{2\,max}$ ($ml.kg^{-1}.min^{-1}$)	2-mile run time (min)	Estimated VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)
Pre (SD)	4.22 ± 0.53	50.8 ± 6.1	15.7 ± 1.4	48.6 ± 5.1
Post (SD)	3.94 ± 0.50	48.5 ± 5.7	17.7 ± 2.5	42.6 ± 7.9
% Change	-6.6[1]	-4.5[1]	12.7[1]	-12.3[1]

[1] Significant change pre- to post deployment ($P<0.01$) based on paired samples t-test.

3.3 Physical Activity Questionnaire

Soldiers were asked to report the frequency (days/week) and duration (min/session) with which they performed aerobic exercise, strength training and/or sports activities for one year prior to deployment and during deployment. These data are in Table 4 for frequency and Table 5 for duration. AF and IQ Soldiers performed aerobic exercise at a lower frequency and duration during deployment than in the year prior to deployment. Pre-deployment, 80% of the AF Soldiers and 88% of the IQ Soldiers performed aerobic exercise three or more days/week. During deployment the percentage was only 35% for AF Soldiers and 29% for IQ Soldiers. In the year prior to deployment 78% of AF Soldiers and 85% of IQ Soldiers performed aerobic exercise for more than 30 min/session. During deployment this figure was only 57% for AF Soldiers and 41% for IQ Soldiers. The AF Soldiers' responses to the frequency of strength training and sports activities tended to show a slight decline, but this was not a significant change from pre- to during deployment. The IQ Soldiers reported fewer strength training days and fewer sports participation days. Surprisingly few Soldiers in the AF cohort (35%) reported participating in sports activities at least one day per week pre-deployment. Sixty percent of the IQ cohort participated in sports activities at least one day per week pre-deployment, but this decreased during deployment to only 14%. The duration of strength training did not change significantly during deployment for either group, but the time allotted for sport activities by the IQ Soldiers declined during deployment.

Table 4: Distribution of responses (%) for aerobid training frequency, strength training frequency and sports participation pre-deployment and during deployment in Soldiers deployed to Afghanistan (AF) and Iraq (IQ).

	Unit	Frequency (days/week)	None	<1	1 to 2	3 to 4	5 to 7	Wilcoxon p-value
Aerobic Training	AF	Pre-deployment	0.0	0.0	20.0	58.2	21.8	<0.01
		During deployment	13.0	24.1	27.7	25.0	10.2	
	IQ	Pre-deployment	1.4	1.4	6.8	46.6	41.1	<0. 01
		During deployment	26.0	21.9	21.9	21.9	6.9	
Strength Training	AF	Pre-deployment	0.9	0.9	40.0	41.8	16.3	0.85
		During deployment	6.5	13.0	25.0	26.9	28.7	
	IQ	Pre-deployment	1.4	4.1	30.1	37.0	26.1	<0. 01
		During deployment	12.3	17.8	24.7	27.4	16.4	
Sports Participation	AF	Pre-deployment	40.9	24.5	23.6	8.2	2.7	0.65
		During deployment	39.8	30.6	21.3	4.7	3.7	
	IQ	Pre-deployment	11.0	28.8	43.8	9.6	5.5	<0. 01
		During deployment	56.2	30.1	8.2	1.4	2.7	

Table 5: Distribution of responses (%)for duration of aerobic training, strength training, and sports participation pre- deployment and during deployment in Soldiers deployed to Afghanistan (AF) and Iraq (IQ).

	Unit	Duration (min/session)	None	<15 min	16-30	31-45	46-60	>60	Wilcoxon p-value
Aerobic Training	AF	Pre-deployment	0.0	0.0	21.8	37.3	22.7	18.2	<0.01
		During deployment	15.7	2.8	25.0	32.4	16.7	7.4	
	IQ	Pre-deployment	2.7	0.0	11.0	24.7	50.7	9.6	<0. 01
		During deployment	27.4	6.8	23.3	15.1	16.4	9.6	
Strength Training	AF	Pre-deployment	0.0	2.7	7.3	40.0	30.0	20.0	0.14
		During deployment	6.5	3.7	15.7	24.1	27.8	22.2	
	IQ	Pre-deployment	1.4	1.4	16.4	34.2	41.1	5.5	0.35
		During deployment	12.3	4.1	13.7	16.4	28.8	23.3	
Sports Participation	AF	Pre-deployment	39.1	0.0	7.3	15.5	19.1	19.1	0.83
		During deployment	38.9	2.8	5.6	9.3	19.4	24.1	
	IQ	Pre-deployment	8.2	1.4	5.5	19.2	42.5	23.3	<0.01
		During deployment	57.5	1.4	5.5	11.0	8.2	15.1	

3.4 Self-Rating of Physical Fitness Components Pre- vs. Post-Deployment

The frequency distribution of AF & IQ Soldiers' self-ratings of physical fitness components are presented in Table 6. Compared to pre-deployment, AF Soldiers reported lower self-ratings for each component of physical fitness following deployment. IQ Soldiers reported lower self-ratings for endurance, sprint speed, and flexibility, but there was no significant change in the distribution of self-rated strength.

Table 6: Percentage distribution of self-ratings of endurance, sprint speed, strength, and flexibility pre- and post-deployment in Soldiers deployed to Afghanistan (AF) and Iraq (IQ).

	Compared to others how would you rate your:		Far less than average	Less than average	Average	Greater than average	Far greater than average	Wilcoxon p-value
Endurance	AF	Pre	1.8	13.6	50.0	30.9	3.6	0.05
		Post	5.6	16.7	48.1	27.8	1.9	
	IQ	Pre	0.0	8.2	47.9	34.2	9.6	0.01
		Post	1.4	19.2	47.9	27.4	4.1	
Sprint Speed	AF	Pre	0.9	10.9	50.0	31.8	6.4	0.01
		Post	3.7	18.5	50.0	22.2	5.6	
	IQ	Pre	0.0	4.1	47.9	42.5	5.5	0.01
		Post	4.1	21.9	42.5	27.4	4.1	
Strength	AF	Pre	0.0	5.5	55.5	31.8	7.3	0.03
		Post	0.9	11.1	54.6	25.9	7.4	
	IQ	Pre	0.0	6.8	65.8	21.9	4.1	0.24
		Post	1.4	15.1	52.1	28.8	2.7	
Flexibility	AF	Pre	4.6	20.2	48.6	23.9	2.8	0.05
		Post	3.7	25.0	56.5	13.9	0.9	
	IQ	Pre	1.4	20.8	51.4	25.0	1.4	0.06
		Post	5.5	28.8	42.5	21.9	1.4	

3.5 Army Physical Fitness Test (APFT) Performance Pre- to Post-Deployment

The units provided matched pre- and post-deployment APFT data for 35% of the 2nd Battalion, 4th Infantry Regiment, 10th Mountain Division deployed to Afghanistan (n=178) and 3% of the Brigade Combat Team, 1st Cavalry Division deployed to Iraq (n=84). These data are presented in Table 7. There were no significant differences in APFT scores pre- to post-deployment in the AF group. In the IQ group, there was little difference in the pre- and post-deployment push-up and sit-up scores but run times averaged 0.7 minutes slower in the post-deployment period (5%), and APFT score was 6 points lower (3%) as compared to pre-deployment.

Table 7: Army Physical Fitness Test (APFT) scores pre- to post-deployment in Soldiers deployed to Afghanistan (AF) and Iraq (IQ).

Variable	N	Pre-deployment (mean±SD)	Post-deployment (mean±SD)	p-value[a]
AF Push-Ups (repetitions)	178	64±13	66±13	0.15
IQ Push-Ups (repetitions)	84	60±14	62±18	0.06
AF Sit-Ups (repetitions)	178	68±11	68±11	0.26
IQ Sit-Ups (repetitions)	83	65±11	63±14	0.28
AF 2-Mile Run Time (min)	178	14.7±1.2	14.6±1.6	0.61
IQ 2-Mile Run Time (min)	76	15.0±1.4	15.7±1.7	<0.01
AF Total Score (points)	178	250±30	250±38	0.83
IQ Total Score (points)	75	236±38	230±45	0.17

[a]From paired t-test

3.6 Injury Incidence Pre- and Post-Deployment

The injury incidence before and after the deployment of the AF and IQ cohorts are listed in Table 8. For the AF cohort, there was no significant difference in injury incidence between the two pre-deployment periods (Periods 1 and 2) and little difference when either of the two pre-deployment periods (Periods 1 and 2) were compared to the first post-deployment period (Period 3). The second post-deployment period (Period 4) had a higher injury incidence than the other 3 earlier periods (Periods 1, 2, or 3).

The IQ cohort also had an increased injury incidence following deployment, but the pattern was different from the AF cohort. The injury incidence was slightly lower in Period 2 than in Period 1. In the post-deployment periods, injury incidence was higher in Period 4 than in Period 3. Injury incidence was more than twice as high in the first post-deployment period compared to the first pre-deployment period (Period 3 versus Period 1). Injury incidence was almost three times as great in the second post-deployment period compared to the first pre-deployment period (Period 4 vs Period 1).

Table 8: Injury Incidence before and after deployment to Afghanistan (AF, n=505) and Iraq (IQ, n=3242).

Cohort	Injury Incidence								p-value (McNemar Test)					
	Pre Deployment				Post-Deployment									
	Period 1		Period 2		Period 3		Period 4							
	n	%	n	%	n	%	n	%	Period1 vs Period2	Period3 vs Period4	Period1 vs Period3	Period1 vs Period4	Period2 vs Period3	Period2 vs Period4
AF	63	12.5	65	12.9	75	14.9	100	19.8	0.91	0.01	0.26	<0.01	0.38	<0.01
IQ	444	13.7	355	11.0	1052	32.4	1307	40.3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

4.0 DISCUSSION

Anecdotally, there has been concern among Army units that soldiers may be returning from combat deployments with lower fitness levels and higher body fat, and that these changes may contribute to injury risk. These data illustrate the changes that occurred in physical fitness, body composition and injury rates after a 9 month deployment to Afghanistan and a 13 month deployment to Iraq. The decreased aerobic power in the IQ group (12%) was more than twice that of the AF group (5%) and may be the source of greatest concern in terms of performance. The measurements made to assess aerobic fitness were different for the two

groups. The treadmill VO2 max test (AF group) is a highly controlled laboratory measure as compared to the 2 mile run test (IQ group), which is more variable and motivationally dependant. A group of Finnish Soldiers who were deployed to Kosovo on a one year peacekeeping mission reported training an average of 117 ± 77 min/week during 1.8 training sessions/week, with large variations from month to month (22). Although more than 70% of the training time was dedicated to strength training, Finnish Soldiers only had a 2.5% decrease in treadmill VO2max and a 5% decrease in 3 km run time. The authors attribute the small decreases in aerobic capacity to high intensity interval running conducted prior to and during the deployment. More than 70% of the Soldiers in deployed to IQ and AF reported a decrease in the frequency of aerobic training during deployment on the post-deployment questionnaire. The decrease in aerobic power in both groups was likely due to this decrease in aerobic training.

Lifting strength (AF group) and lower body strength (IQ group) did not change pre- to post-deployment. Upper body anaerobic power decreased approximately 5% in the AF group, but increased 9% in the IQ group along with an increase in bench press strength of 7%. The increase in strength and upper body anaerobic power in the IQ group is surprising considering 54% of IQ Soldiers reported a decrease in the frequency of strength training during deployment as compared to pre-deployment. It is possible that the duty tasks performed by the IQ Soldiers provided an adequate training stimulus to improve both upper body strength and power.

Finnish Soldiers performed a fitness test consisting of a 3 km run, sit-ups, push-ups and chin-ups (22) prior to and at the end of a peacekeeping deployment to Kosovo (22). The pre- to post-deployment fitness test changes in the Finnish Soldiers were similar to the changes in APFT performance for the US Soldiers. The sit-up and push-up performance was not changed and run time was most affected. There was an increase in run time of nearly 5% in Finnish Soldiers, which is similar to the change in APFT run time for the larger cohort of IQ Soldiers (see Table 7). The AF Soldiers did not demonstrate a decrease in 2 mile run time, but the APFT tests were conducted several months before and after the deployment period and the loss in aerobic power may have been recovered at that point.

The changes in body composition from pre- to post-deployment were not large and the two deployment groups differed in the pattern of the changes. In AF Soldiers there was a small decrease in body mass following deployment, which was comprised of a decrease in lean mass and an increase in body fat. In contrast, IQ soldiers gained 3% body mass, which is similar to the 3.5% increase in body mass reported for Finnish Soldiers deployed to Kosovo (22). The IQ Soldiers gained both fat mass and lean body mass. Using Spearman's Rank-Order Correlation coefficient, a positive relationship ($p<0.05$) was found between changes in lean mass and strength training frequency (AF $r=0.35$, IQ $r=0.34$) and duration (AF $r=0.34$, IQ $r=0.25$) during deployment. Soldiers who participated in strength training more frequently and for longer periods of time during deployment tended to have increases in lean mass. The increase in fat mass in both samples may be associated with the reduction in aerobic exercise frequency and duration during deployment. Additionally, previous studies have demonstrated that among individuals who run as their primary means of aerobic training, steady state training results in a weight-stable condition, while an inverse, nonlinear relationship exists such that decreasing running mileage results in increases in body fat and is most pronounced when training is stopped (23). Dyrstad (22) reports that the Finnish Soldiers who increased VO2max during deployment trained for longer time periods and did not gain body mass from pre- to post-deployment to Kosovo.

Both groups experienced a post-deployment increase in injuries, but the two groups differed in terms of pattern and size of the increase. The AF cohort showed very little immediate post-deployment rise in injury incidence (Period 3) but a larger increase later (Period 4); the IQ cohort showed an immediate post-

deployment increase (Period 3) and a larger increase later (Period 4). The absolute increase in the post-deployment injury incidence in the AF group was less than half that of the IQ cohort.

The lower overall post-deployment injury incidence in the AF cohort could be due to a number of factors, among which might be 1) the time of year when the first post-deployment period occurred, 2) the physical training program the unit was using, 3) the differences in the occupational tasks of the Soldiers, and/or 4) in-theatre differences. With regard to the time of year, the AF cohort returned from deployment in December and there was little field training at this time. Soldiers also had 2 weeks of block leave during the holiday season at the end of December and there were generally few visits for injuries over block leave period (4). The IQ cohort post-deployment period began on 3 January and thus the holiday block leave period was not included.

In addition to the time of year, we observed that the AF deployed units had implemented the new Physical Readiness Training (PRT) program prior to deployment and continued to use the PRT program after deployment (24). PRT is the new US Army physical training doctrine designed by the US Army Physical Fitness School to improve Soldiers' physical capability for military operations. In both Basic Combat Training and in Ordnance Advanced Individual Training, PRT has been shown to substantially reduce the overall incidence of injury (25-27) and it is possible that it reduced the injury incidence in the AF cohort. The IQ cohort was using the more traditional physical training doctrine as described in Army Field Manual 21-20 (28).

It is possible that differences in the occupational tasks of the Soldiers may have influenced differences in the pattern and magnitude of the post-deployment injury rates. We requested from the AFHSC the military occupational specialties (MOSs) of the Soldiers involved in the project. There were 401 of the 505 Soldiers in the AF group (79%) that had an (infantry specialty), with the remainder having specialties that included artillery (n=32), signal (n=23), medical (n=24) and other (n=25). Only 626 of the IQ cohort (19%) had an infantry specialty with a wide variety of other specialties, as would be expected since the cohort was comprised of an entire brigade. Thus, occupational tasks differed in the two cohorts.

Overall, the Soldiers returning from deployment did not demonstrate large changes in strength, aerobic performance or body composition. The negative changes will likely be ameliorated with a directed physical training program upon return from deployment. The elevated post-deployment injury incidence is a concern and deserves further study to identify risk factors and implement injury interventions.

NOTE: The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Army or the Department of Defense.

5.0 REFERENCE LIST

1. Knapik JJ, Darakjy S, Hauret KG, Canada S, Scott S, Rieger W, Marin R, Jones BH. Increasing the physical fitness of low-fit recruits before basic combat training: an evaluation of fitness, injuries, and training outcomes. *Mil Med*. 2006;171(1):45-54.

2. Knapik JJ, Sharp MA, Canham-Cherval M, Hauret K, Patton JF, Jones BH. Risk factors for training-related injuries among young men and women in basic combat training. *Med Sci Sports Exerc*. 2001;33(6):946-54.

3. Knapik J, Ang P, Reynolds K, Jones B. Physical fitness, age, and injury incidence in infantry soldiers. *J Occup Med*. 1993;35(6):598-603.

4. Knapik JJ, Spiess A, Grier T, Lester M, Sharp M, Tobler S, Swedler D, Jones BH. Injuries and physical fitness before and after deployments of the 10th Mountain Division to Afghanistan and the 1st Cavalry Division to Iraq, August 2005-June 2007. Aberdeen Proving Ground, MD: US Army Center for Health Promotion and Preventive Medicine; 2009. Report No.: 12-HF-05SR-05. 1-40 p.

5. Sharp MA, Knapik JJ, Walker LA, Burrell L, Frykman PN, Darakjy SS, Lester ME, Marin RE. Physical Fitness and Body Composition after a 9-Month Deployment to Afghanistan. *Med Sci Sports Exerc*. 2008.

6. Bonnick SL, Miller PD. *Bone densitometry in clinical practice*. 2nd ed. Totowa, NJ: Humana Press; 2004. 69-81 p.

7. Stevenson JM, Bryant JT, French SL, Greenhorn DR, Andrew GM, Thomson JM. Dynamic analysis of isoinertial lifting technique. *Ergonom*. 1990;33(2):161-72.

8. Sharp MA, Rice VJ, Nindl BC, Williamson TL. Maximum lifting capacity in single and mixed gender three-person teams. In Proceedings of the Human Factors and Ergonomics Society 37th Annual Meeting; Santa Monica, CA: Human Factors and Ergonomics Society; 1993. p. 725-9.

9. Semenick DM. Testing Protocols and Procedures. In: Baechle TR, editor. *Essentials of Strength Training and Conditioning*. Champaign,IL: Human Kinetics; 1994. p. 258-73.

10. Matuszak ME, Fry AC, Weiss LW, Ireland TR, McKnight MM. Effect of rest interval length on repeated 1 repetition maximum back squats. *J Strength Cond Res*. 2003;17(4):634-7.

11. Wyss T, Hubner K, Mader U. Seated shot put as a measurement of explosive upper body power. In: Hakkinen K, Kyolainen H, editors. International Congress on Soldiers' Physical Performance; 5 A.D. May 18; Jyvaskyla,Finland: University of Jyvaskyla; 2005. p. 154.

12. Harman EA, Rosenstein MT, Frykman PN, Rosenstein RM, Kraemer WJ. Estimation of human power output from vertical jump. *J Appl Sport Sci Res*. 1991;5(3):116-20.

13. Markovic G, Dizdar D, Jukic I, Cardinale M. Reliability and factorial validity of squat and countermovement jump tests. *J Strength Cond Res*. 2004;18(3):551-5.

14. Alemany JA, Pandorf CE, Montain SJ, Castellani JW, Tuckow AP, Nindl BC. Reliability assessment of ballistic jump squats and bench throws. *J Strength Cond Res*. 2005;19(1):33-8.

15. Thomas GA, Kraemer WJ, Spiering BA, Volek JS, Anderson JM, Maresh CM. Maximal power at different percentages of one repetition maximum: influence of resistance and gender. *J Strength Cond Res*. 2007;21(2):336-42.

16. Kraemer WJ, Mazzetti SA, Nindl BC, Gotshalk LA, Volek JS, Bush JA, Marx JO, Dohi K, Gomez AL, Miles M, et al. Effect of resistance training on women's strength/power and occupational performances. *Med Sci Sports Exerc*. 2001;33(6):1011-25.

17. Sharp MA, Patton JF, Knapik JJ, Hauret K, Mello RP, Ito M, Frykman PN. Comparison of the physical fitness of men and women entering the U.S. Army: 1978-1998. *Med Sci Sports Exerc*. 2002;34(2):356-63.

18. Mello RP, Murphy MM, Vogel JA. Relationship between a two mile run for time and maximal oxygen uptake. *J Appl Sport Sci Res*. 1988;2(1):9-12.

19. Knapik JJ, Jones BH, Reynolds KL, Staab JS. Validity of self-assessed physical fitness. *Am J Prev Med*. 1992;8(6):367-72.

20. Department of the Army H. Physical fitness training FM 21-20. Washington, D.C.: U.S. Government Printing Office; 1992.

21. Fleiss JL. *Statistical methods for rates and proportions*. New York: John Wiley & Sons; 2003.

22. Dyrstad SM. Physical Fitness, Training Volume, and Self-Determined Motivation in Soldiers during a Peacekeeping Mission. *Milit Med*. 2007;172(2):121.

23. Williams PT. Incident hypercholesterolemia in relation to changes in vigorous physical activity. *Med Sci Sports Exerc*. 2009;41(1):74-80.

24. Knapik JJ, Rieger W, Palkoska F, Van Camp S, Darakjy S. United States Army physical readiness training: Rationale and evaluation of the physical training doctrine. *J Strength Cond Res*. 2009; 23(4):1353-62.

25. Knapik JJ, Bullock SH, Canada S, Toney E, Wells JD, Hoedebecke E, Jones BH. Influence of an injury reduction program on injury and fitness outcomes among soldiers. *Inj Prev*. 2004;10(1):37-42.

26. Knapik J, Darakjy S, Scott SJ, Hauret KG, Canada S, Marin R, Rieger W, Jones BH. Evaluation of a standardized physical training program for basic combat training. *J Strength Cond Res*. 2005;19(2):246-53.

27. Knapik JJ, Hauret KG, Arnold S, Canham-Chervak M, Mansfield AJ, Hoedebecke EL, McMillian D. Injury and fitness outcomes during implementation of physical readiness training. *Int J Sports Med*. 2003;24(5):372-81.

28. FM 21-20 Physical Fitness Training. 1998. Washington, DC, Headquarters, Dept of the Army.